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HEREDITY OF SKIN PIGMENT IN MAN. II

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E. INHERITANCE OF ALBINISM

Albinism is the absence of pigmentation through lack of either, or both, the chromogen and the oxidizing ferment. The condition occurs widespread among animals and plants. In man it is rather rare, probably not occurring (if one may hazard a mere guess) in the population of the United States, as a whole, in more than in one case in 10,000 people.

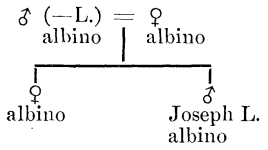
Of true albinism in man there are all degrees. Aside from the piebald condition occasionally found in colored persons there are various grades of uniform depigmentation—hair color varying from light yellow to pure white; irides varying from pale blue to absence of blue, and pupils varying in the intensity of the pink color. Indeed, there is abundant testimony that persons born as albinos may acquire a slight pigmentation. Such a case was cited by Dr. H. B. Young (1905) from Illinois. Albino cats also vary in the pinkish glow of the retina.

Despite variations in the completeness of depigmentation albinism can usually be clearly distinguished, at least in its more marked grades, and so we can study its inheritance. The cases given below were mostly col-

lected by ourselves alone, or with the aid of a medically trained assistant, Dr. Sumner Everingham, and many of the albinos were seen by us.

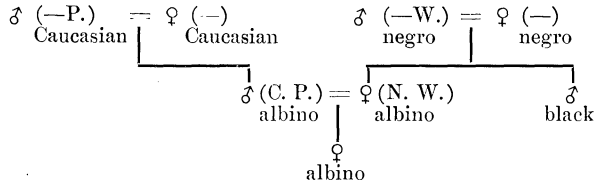
I. BOTH PARENTS ARE ALBINOS

1. LUC. FAMILY



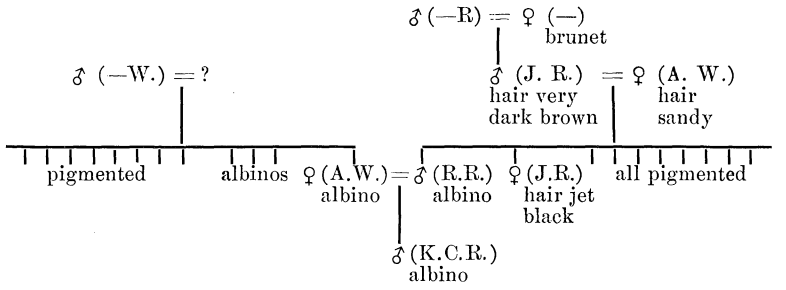
Note.—This case is on the authority of Mr. Rob Roy, an albino who seems entirely trustworthy, and has met many albinos in the "show" business.

2. PRI. FAMILY



Note.—This case also on the authority of Rob Roy.

3. R. FAMILY

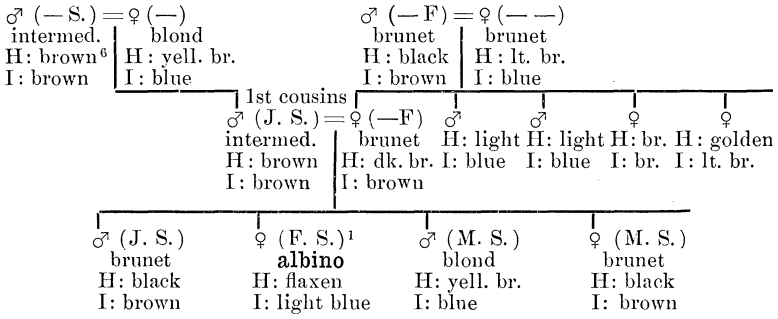


Note.—R. R. seen by me.

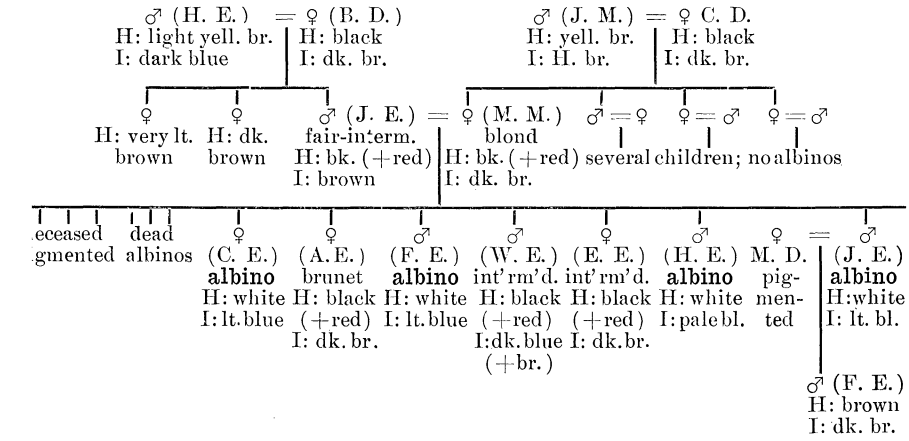
II. Neither Parent Albinic

(*a*) *Albinos in Caucasian Families with Admitted Consanquinity*

4. She. Family



5. Enn. Family (Irish Origin)

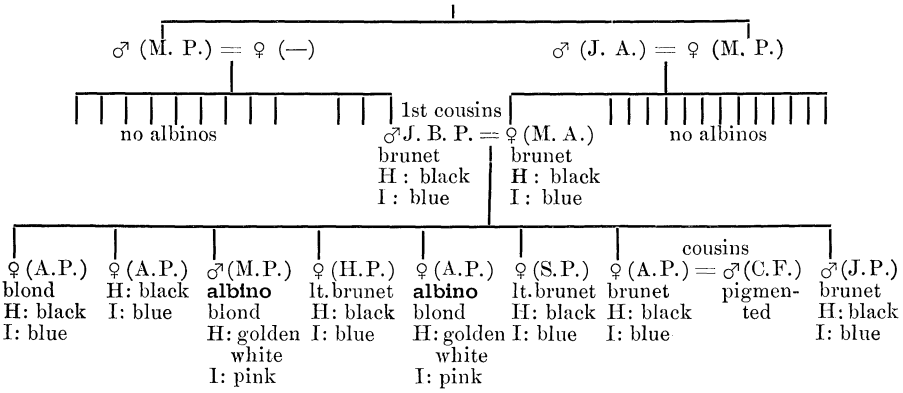


Note.—Three generations known; no other albinos. The father and mother, JE and MM, are distant cousins (not first); and father's mother and mother's mother bear the same surname and come from the same place in Ireland. The youngest son (JE) married a distant cousin having the same surname as both his grandmothers. Seen by C. B. D.

[6] In the pedigree tables H indicates hair color; I iris color.

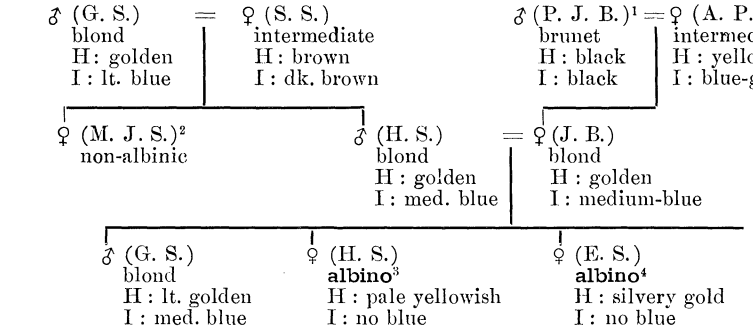
[7] Hair faintly yellowish; irides pale blue; retina, medium pinkish glow; nystagmus moderate; congenital myopia; school work satisfactory; father and mother first cousins. Seen by S. E.

6. PAR. FAMILY



(b) *Albinos in Families with Suspected Consanquinity*

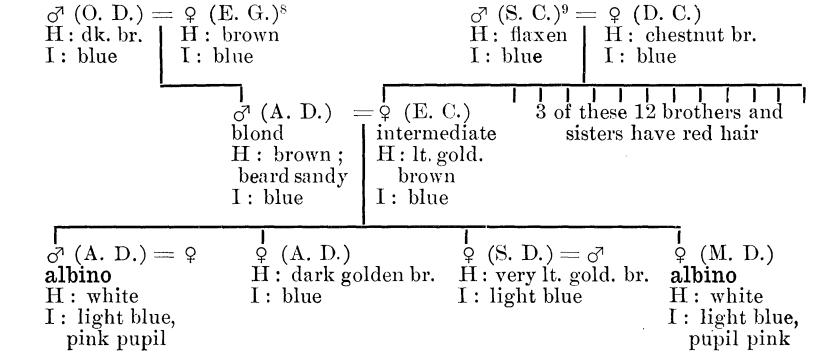
7. SAC. FAMILY



Note.—Seen by C. B. D. and S. E. [1] and [2] have the same middle name. [3] and [4] show reddish glow through pupil.

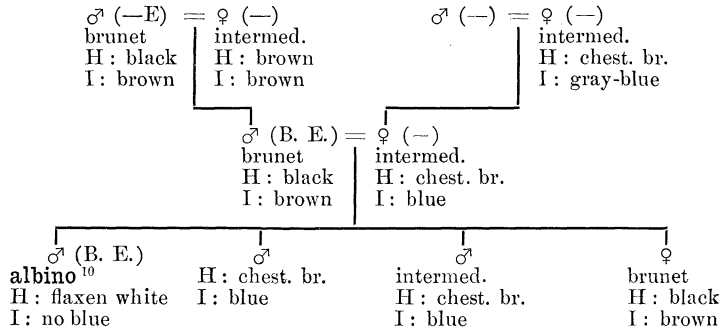
(c) *Albinos in Caucasian Families with no Evidence of Consanguinity*

8. DON. FAMILY (IRISH ORIGIN)



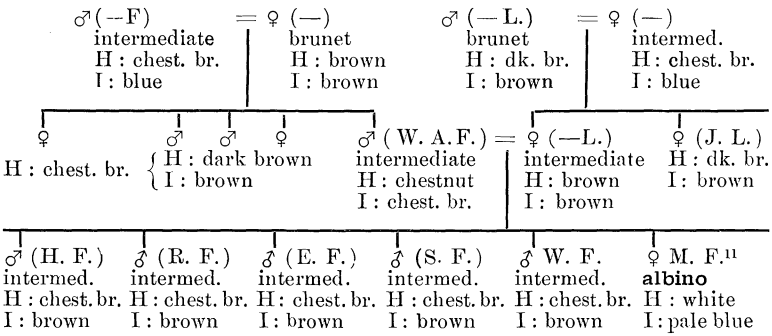
Note.—Seen by C. B. D. No relative on either side known to be an albino.

9. Ed. Family



Note.—Seen by S. E.

10. Far. Family



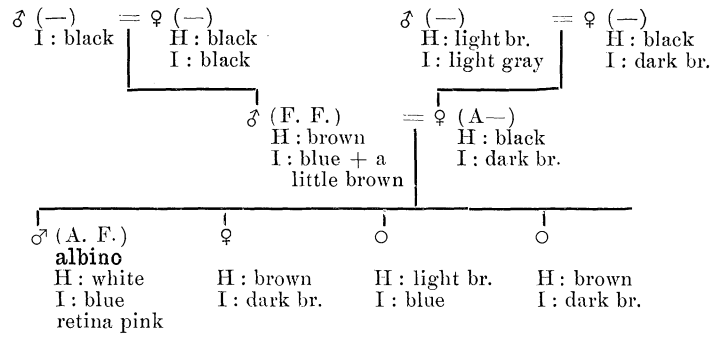
[8] Some relatives with sandy hair.

[9] Many of his relatives have red hair.

[10] Hair white as snow; retina with bright pinkish glow; nystagmus moderate; shortsighted; can read 9 pt. Modern (Roman) type at three inches from eyes; school work middling. Red hair in ancestry, three generations back.

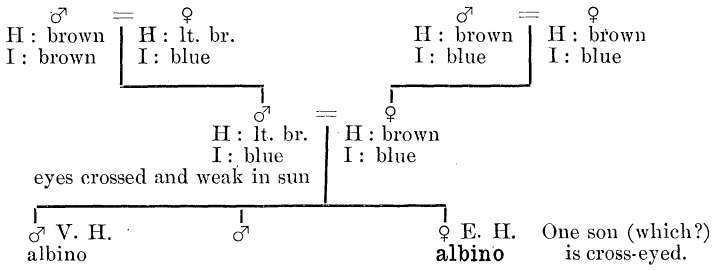
[11] Seen by S. E. Retina, medium pinkish glow; nystagmus slight; reads No. 9 Modern (Roman) print at nine inches; school work satisfactory. No consanguinity known.

11. FER. FAMILY (ITALIAN)

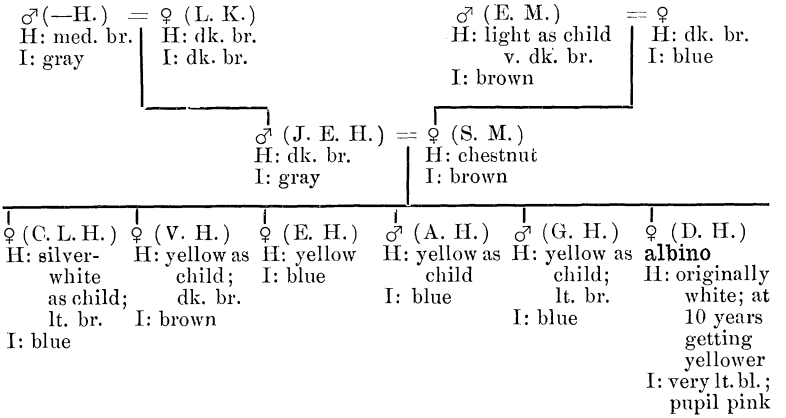


Note.—Seen by C. B. D. No consanguinity so far as known. No other albino relatives recalled.

11a. HLO. FAMILY (BOHEMIAN)

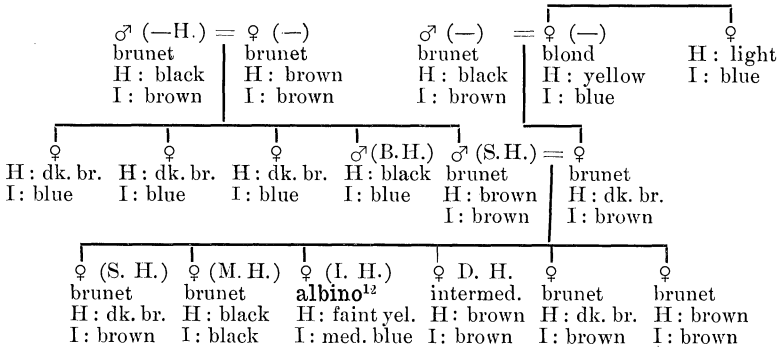


12. HOR. FAMILY



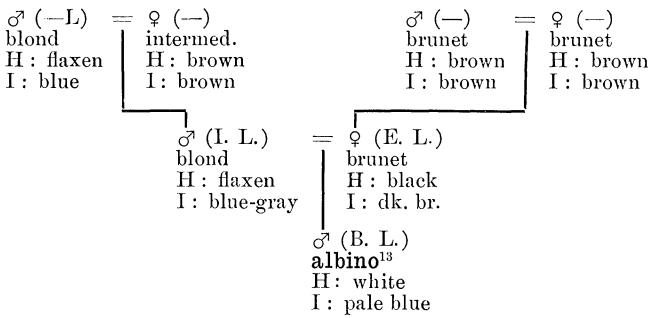
Seen by C. B. D. Nystagmus present.

13. Huf. Family (German Origin)



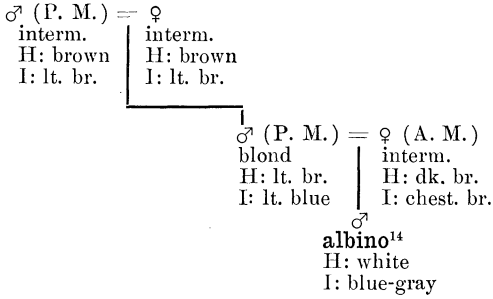
Seen by S. E.

14. Lie. Family



Seen by S. E.

15. Mcg. Family



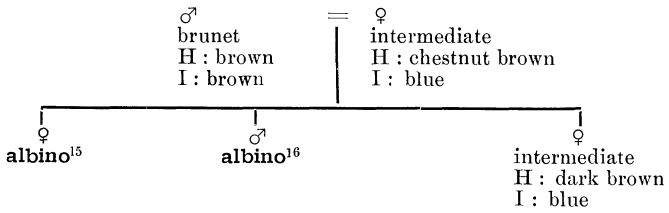
Seen by S. E.

[12] Retina with slight pinkish glow; nystagmus present in moderate degree; congenital hypermetropia.

[13] Retina pigmented; nystagmus present; nearsighted.

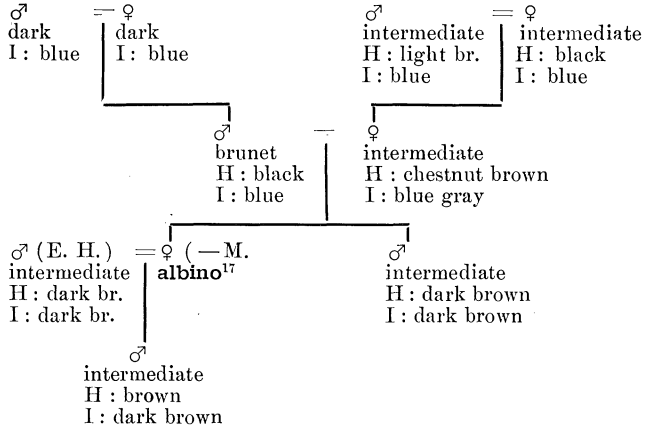
[14] Retina pinkish; nystagmus present; very slight internal strabismus; general intelligence; average at school work, reads readily; sight good except in bright light.

16. MCK. FAMILY



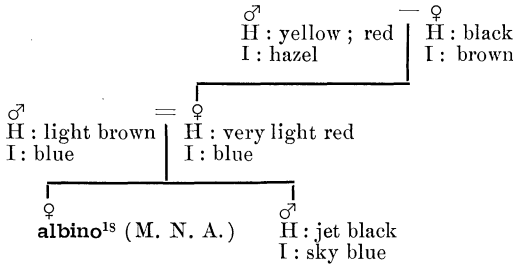
Seen by S. E.

17. MOO. FAMILY



Seen by S. E.

18. NEA. FAMILY



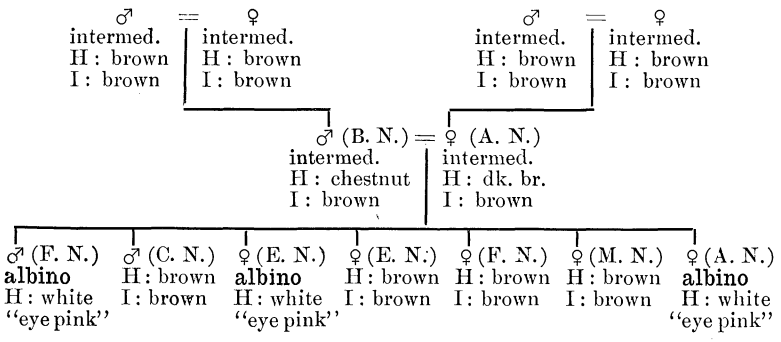
[15] Hair white; iris pale blue; retina pinkish as seen through pupil; nystagmus present; slight internal strabismus; work at school very difficult, sight growing weaker.

[16] Details as above. Eyes stronger, can read No. 9 point at 18 inches.

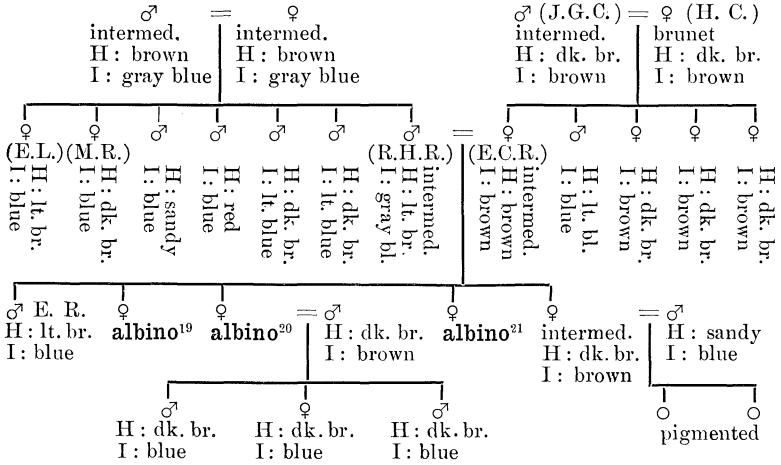
[17] Hair white; iris light blue, retina dark (almost black), nystagmus present, has congenital high degree of myopia. Fairly good at school, can see to sew at night, bright in conversation.

[18] Complexion very fair, hair white, iris clear blue.

19. Nog. Family (Italian)

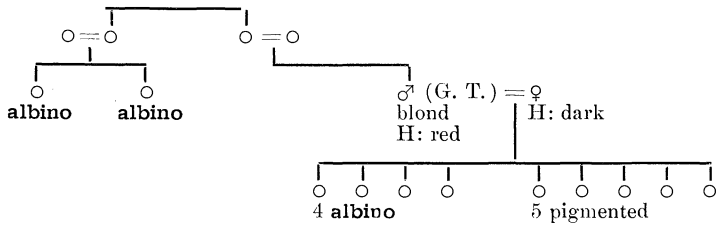


20. Rid. Family



Seen by S. E.

21. Tho. Family

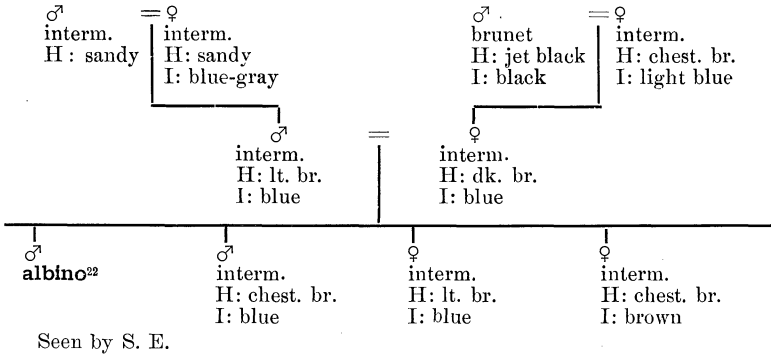


[19] Hair, faintly yellowish; iris, devoid of blue; retina with medium pinkish glow; nystagmus moderate; myopia, school work satisfactory; read a good deal; sparetime spent in weaving seats of cane chairs.

[20] Hair faintly yellowish; iris devoid of blue; retina with medium pinkish glow; nystagmus moderate; myopia; school work middling.

[21] Hair faintly yellowish; iris pale blue; retina with medium pinkish glow; nystagmus moderate; myopia; school work middling.

22. WIL. FAMILY

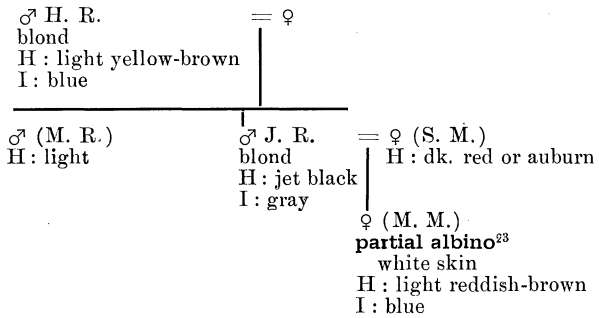


Seen by S. E.

23. The P-W family. The relationships of the members of this family, so far as worked out, are shown in the diagrams 23*a*, 23*b*, 23*c* and 23*d*. The persons in these diagrams come from the same general region and several surnames are common, especially those indicated by the initials P and W. The frequent recurrence of the same four surnames in the paternal and maternal sides of the ancestry of most of these albinos is testimony to a wide spread consanguinity. Further details are reserved for a later paper when it is hoped the pedigrees can be extended and connected.

(*d*) *Colored Families*

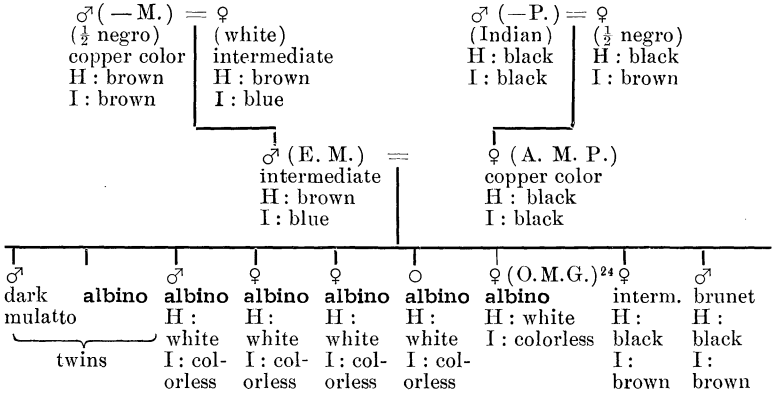
24. MER. FAMILY



[22] Hair white; iris pale blue; retina bright pink; nystagmus marked; eyes sensitive to bright light, sees better in half light. "Kept up with the rest in school."

[23] Seen by C. B. D. Retina not pink. Slight nystagmus.

25. MAN. FAMILY



Seen by S. E.

25. Under this head may be cited the observations of Dr. Hrdlicka, who has collected data concerning ten albino Hopi Indians and two albino Zuni.

It appears from his data that "albinos marry full-colored individuals of the opposite sex. They seldom raise any children and never have large families of their own." All of the albinos whose data follow have a pinkish-white skin and gray-blue or blue eyes. The color of hair varies from flaxen to light brown.

A summary of the data relating to inheritance of albinism is given in Tables A and B.

TABLE A

GIVING THE COLOR CONDITION OF THE FRATERNITY OF EACH ALBINO DESCRIBED. THE PARENTS ARE, IN ALL CASES, OF NORMAL COLOR.

No.	Sex.	Number of Fraternity.		No.	Sex.	Number of Fraternity.	
		Normal.	Albinic.			Normal.	Albinic.
1	♀	2+?	1	7	♀	4 or 5	1
2	♀	1+!	1	8	♀	2	1
3	♀	2	1	9	♀	1	1
4	♂	3	1	10	♂	3	1
5	♂	4	1	11	♂	7	1
6	♀	4	2	12	♂	4	2
				Total		37+ or 38+	14

[24] Retina pinkish; nystagmus present; myopic; can read nine point print at five inches.

TABLE B

GIVING THE NUMBER OF NORMAL AND OF ALBINIC OFFSPRING OF AN ALBINIC INDIVIDUAL MARRIED TO A NORMAL.

N, normal; A, albinic, D, the dominant character; R, the recessive.

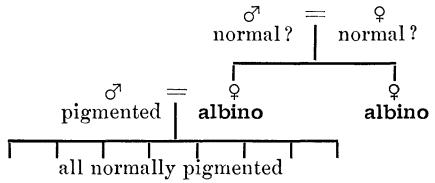
D	R	DR (=N)	RR (=A)
N♀	A 4♂[25]	0	0
N♂	A 7♀	0	0
N♂	A 9♀	1	0
N♀	A11♂	1	0
		2	0

If we consider *both* parents of the fourteen albinos listed in Table A as simplex in pigment, *i. e.*, as having not only normal but also albinic germ-cells, they were "DR's." When two such simplex (DR) individuals are mated, we expect 25 per cent. of the offspring to be duplex (DD), 50 per cent. simplex (DR or RD), and 25 per cent. without pigment (RR). Only the last will be albinic, 75 per cent. will be of normal color. We actually find that with fourteen albinos there are associated in their fraternities 37 + or 38 + normal individuals, expectation being 42. The deficiency would doubtless be accounted for by the unincluded normal children. Since the proportion of albinic offspring in the given fraternities accords with expectation on the assumption that albinism is recessive that assumption is justified.

Second, if albinism is recessive, it should not appear in offspring of albinos with normal consorts. Unfortunately the sterility of the cross makes it difficult to get the desired data, but so far as they go, they are not in disaccord with hypothesis.

III. ONE PARENT ALBINIC

26. EDD. FAMILY



[25] These numbers refer to the serial numbers of the cases as given in Table A.

27. ENN. FAMILY (CONTINUATION OF No. 5)

♂ (J. E.) = ♀ (M. D.)
albino | H : black
I : dk. br.
|
♂
H : brown
I : dk. br.

28. MAN. FAMILY (CONTINUATION OF No. 24)

♀ (O. M. G.) = ♂
albino | pigmented Caucasian
H : brown
I : brown
|
○
albino
+ 5 yrs. old

29. MOO. FAMILY (CONTINUATION OF No. 17)

♀ (—M.) = ♂ (E. H.)
albino | intermed.
H : dk. br.
I : brown
|
♂
intermed.
H : brown
I : dk. br.

30. NEA. FAMILY (CONTINUATION OF No. 18)

♀ (M. N. A.) × ♂
albino | pigmented

♀	♀	♀	♂
H: lt. br. I: lt. blue	H: brown I: blue	H: blond I: blue	H: jet black

31. RID. FAMILY (CONTINUATION OF No. 20)

♂ (R. H. R.) = ♀ (E. C. R.)
intermed. | interm.
H: lt. brown | H: brown
I: gray blue | I: brown

♂	♀	♀	=	♂	♀	♀
interm. H: lt. br. I: blue	**albino**	**albino**		H: dk. br. I: brown	**albino**	interm. H: dk. br. I: brown

♂	♀	♂
H: dk. br. I: blue	H: dk. br. I: blue	H: dk. br. I: blue

IV. THE D. G. V. FAMILY (see Plate)

This remarkable family comprises a great mixture of white, negro and even Indian blood, as well as many consanguineous marriages. The MAN family comes from the same rural community, but its connections with the D. G. V. family have not yet been established. It will be observed that every albino has the blood of all three families D., G. and V., so it can not be said, at present, from which family albinism originally came. It will be noted, also, that both of the youngest family (whose history is best known) arise from cousin marriages. Considering only those families in which albinism actually occurs there are 8 albinos in 22 children, which is a greater proportion than the expected 25 per cent. (5 or 6 albinic offspring). It is clear, however, that it may well be that there is potential albinism in one or more of the families with 3 to 5 children, in which by chance it fails to appear—the 22 children are merely a minimum.

Details about some of the persons in this family follow:

V.[1] 7, Yellowish complexion, brown hair and iris.

V. 8, Yellowish complexion, light brown hair, blue iris.

V. 9, An almost white mulatto, very light brown hair, blue iris.

V. 10, An almost white mulatto, brown hair, blue iris.

VI. 4, Intermediate complexion, light brown hair, gray iris.

VI. 5, Yellowish complexion, light brown hair, blue iris.

VII. 1, T. V., aged 3, albino, hair white, iris colorless, retina with pinkish glow, nystagmus present, intellectually bright and well developed.

VII. 2, F. V., aged 4, intermediate complexion, hair and iris dark brown.

VII. 3, M. V., aged 1, brunet, hair and iris black.

V. 20, J. V. (Indian, French and negro blood), yellow skin, very light brown hair, yellow iris.

[25a] The Roman numeral refers to the generation; the Arabic to the individual.

TABLE IX

SHOWING THE HAIR AND EYE COLOR OF PARENTS AND GRANDPARENTS OF ALBINOS ARISING FROM PIGMENTED PARENTS

No.	Name.	Father.		Mother.		F.F.		F.M.		M.F.		M.M.	
		Hair.	Eye.	Hair.	Eye.	Hair.	Eye.	Hair.	Eye.	Hair.	Eye.	Hair.	Eye
4.	She.	br	br	dk.br	br	br	br	yell.br	bl	N	br	lt.br	bl.
5.	Enn.	N+R	br	N(+R)	dk.br	lt.yell.br.	dk.bl	N	dk.br	yell.br	lt.br	N	dk.br
7.	Sac.	gold	bl	gold	bl	gold	lt.bl	br	dk.br	N	N	yell.br	bl.gr
7a.	Bro.-7	dk.br	N	dk.br	bl.	—	—	—	—	—	—	—	—
8.	Don	br+R	bl	lt.goldbr.	bl	dk.br	bl	br	bl	flax	bl	chest.br	bl
9.	Ed.	N	br	chest.br	bl	N	br	br	br	—	—	chest.br	gray bl
10.	Far.	chest	chest.br	br	br	chest.br	bl	br	br	dk.br	br	chest.br	bl
11.	Fer.	br	bl	N	dk.br	N	—	N	N	lt.br	lt.gray	N	dk.br
11a.	Hlo.	br	bl	br	bl	br	lt.br	br	br	br	bl	br	bl
12.	Hor.	dk.br	gray	chest	br	br	gray	dk.br	dk.br	lt. to dr.br	br	dk.br	bl
13.	Hut.	br	br	dk.br	br	N	br'	br	br	N	br	yell.	bl
14.	Lie.	flax	bl.gray	N	dk.br	flax	bl	br	br	br	br	br	br
15.	Mcg.	lt.br	lt.bl	dk.br	chest.br	br	lt.br	br	lt.br	—	—	—	—
16.	Mck.	br	br	chest.br	bl	—	—	—	—	—	—	—	—
17.	Moo.	N	bl	chest.br	bl.gray	—	bl	—	bl	lt.br	bl	N	bl
18.	Nea.	lt.br	bl	v. lt. red	bl	—	—	—	—	yell.red	hazel	N	br
19.	Nog.	chest	br	dk.br	br	br	br	br	br	br	br	br	br
19a.	Pit.	N	N	dk.br	bl	light	blue	N	N	light	bl	N	br
20.	Rid.	lt.br	gray bl	br	br	br	gray bl	br	gray bl	dk.br	br	dk.br	br
21.	Tho.	red	—	dark	—	—	—	—	—	—	—	—	—
22.	Wil.	lt.br	bl	dk.br	bl	sandy	—	sandy	bl.gray	N	N	chest.br	lt.bl

V. 21, M. (Irish origin), brunet, black hair, blue iris.

VI. 10, J. V., Brunet, brown hair, blue iris.

VI. 11, S. G., Intermediate complexion, brown hair and iris.

VII. 15, A. V., Aged 18, albino, white hair, colorless iris, retina pinkish, nystagmus present, mentally quick.

VII. 18, L. V., Aged 24, albino, white hair, colorless iris.

V. THE CONDITION OF HAIR AND EYE COLOR IN THE PIGMENTED PARENTS OF ALBINOS

Assuming all pigmented parents of albinos to be simplex in pigment we may inquire if such simplex parents differ from the population at large in their hair and eye color. To get an answer to this inquiry Table IX has been drawn up.

This table is summarized in Table X, so as to bring out the relative frequency of the different types.

TABLE X

THE RELATIVE FREQUENCY OF THE DIFFERENT TYPES OF HAIR AND EYE COLOR IN THE PARENTAGE OF ALBINOS

Hair Color.								Eye Color.							
Types.	F.	M.	FF.	FM.	MF.	MM.	Total.	Types.	F.	M.	FF.	FM.	MF.	MM.	Total.
N (black)	3	2	3	3	3	5	19	N (black)	2			2	2		6
dk. br.	2	8	1	1	2	2	16	dk. br.		3		3		2	8
br.	5	3	6	10	4	3	31	br.	6	6	4	5	7	5	32
lt. br.	4				2	1	7	lt. br.			2	1	1		4
golden	1	2	2	1	1	1	8	chest. br.	1	1					2
yellow						1	1	hazel					1		1
flaxen	1		1		1		3	gray	1		1		1		3
red+N	1	1					2	blue-gray	2	1	1	2		2	8
red+dk.br.	1						1	blue	7	9	6	4	4	7	37
chestnut	2	4	1			3	10	lt. blue	1		1			1	3
red	1	1			1		3								
Total	21	21	14	15	14	16	101	Total	20	20	15	17	16	17	105

If Table X be compared with the proportional distribution of the different types of hair color in the population at large, certain differences are seen. Thus while black, dark brown and brown hair constitute in a random

population (Holmes and Loomis, 1909, p. 55) 695 out of 853 persons, or 81.5 per cent., in Table X, they constitute only 65 per cent. On the other hand, while, according to Holmes and Loomis (1909, Table III), red and auburn constitute only about 5.5 per cent. of their population, the various forms of red constitute 16 per cent. of the population of Table X, or three times the typical proportion. It appears then that, on the whole, the pigmented ancestry of albinos shows an excess of red and the weaker grades of melanic pigment.

The distribution of eye color, on the other hand, shows little that is abnormal. The "blacks" are somewhat deficient, about 70 per cent. as abundant as in the population as a whole, the browns are in excess, and the blues occur in nearly normal proportions. The last result was hardly anticipated as it might have been expected that the pale blue iris of the albino would be specially apt to proceed from blue-eyed parents, but this is not so. As a matter of fact, dark brown eyes are quite compatible with recessive albinism as Table XI shows. The general teaching of Table XI is that the heterozygous or simplex pigmentation of the offspring is not always clearly less than that of the darker parent. But, on the whole, blue iris predominates slightly and the hair tends to run

TABLE XI

SHOWING THE HAIR AND IRIS COLOR OF THE OFFSPRING OF AN ALBINO AND A PIGMENTED PARENT

Family.	Parents.			Offspring.	
	Albino.	Pigmented Parent.		Hair Color.	Iris Color.
		Hair Color.	Iris Color.		
Enn.	♂	N	dk. br.	br	dk. br.
Moo.	♀	dk. br.	dk. br.	br.	dk. br.
Nea	♀	pigmented	pigmented	lt. br.	lt. br.
				br.	blue
				blond	blue
				jet black	—
Rid.	♀	dk. br.	br	dk. br.	blue
				dk. br.	blue
				dk. br.	blue

lighter than, or at least not to exceed, that of the darker parent.

VI. THE ORIGIN AND "CAUSE" OF ALBINISM

The question remains to be discussed: What is the origin and "cause" of these albinos. The general conclusion seems justified, as in other mammals so in man, albinism is due to the fortuitous union of two germ-cells lacking this factor so that it is absent in the zygote whence the albino proceeds.

The objections to this view are three: (1) The usual absence of any history of albinism in the family; (2) the improbability of so frequent unions of two persons bearing albinism recessive; (3) the lack of statistical accord of the results of human breeding with those of animals.

The first objection is not valid for any one who has done experimental breeding, because he knows full well how the recessive condition may be carried unexpressed in the germ-cells for many generations awaiting that chance conjugant that also carries the recessive condition. Absence of any history of albinism in a family has the less significance in a country like ours where a large proportion of the population can not tell the names of their grandparents and know little of their cousins, who may, indeed, live one to three thousand miles away.

The improbability of so frequent unions of two or three persons having albinism recessive has been referred to by Pearson. With a mathematical showing, he tells the story of an albino who married successively two pigmented (?) husbands and had some albino children by each. "All three stocks, according to Mendelian hypothesis, ought to have albinism in a recessive form. You can calculate the chances against that because an albino occurs in Italy about 1 in 30,000, in Norway, about 1 every 20,000 of the population, in Scotland, 1 in 24,000. What are the chances that a woman of albinotic stock should marry two stocks affected with albinism and not related either to her or to each other?" The inference

seems to be that Pearson would be content with "calculating the chances" and, because the ratio was small, insisting that the three stocks could not all have albinism recessive. Such a method of procedure is, I fear, all too characteristic of the "careful work" which alone, according to its editor, is admitted to the pages of *Biometrika*.[26] Of course the facts are that we have here no data for calculating the required chances. In the first place, the term "not related" has only a relative significance in the statistics of human qualities; it usually means not first cousin or nearer relative, more rarely extends to second cousin, or at the outside, to third cousin. And yet two persons of the grade of tenth cousin may easily carry recessive an albinic condition derived from a common source. A fairer question would be, what are the chances that a woman shall marry in succession two men related between the grades of third and tenth cousin, supposing, further, all three come from the same rural district, long settled and relatively stable? I think the conditions that Pearson does not cite might easily render the chances several million to one in favor of the three persons being less distantly related than tenth cousin. An actual illustration of this condition of affairs is shown in the D. G. V. and P. W. families. The three family names represented by D., G. and V. occur again and again in this family, as the pedigree table shows. Some of the consorts are recognized as "first cousins"; but in most other cases they are stated to be "unrelated." If the inquiry is pressed the admission is made "were perhaps *distantly.*" One may "calculate the chances" that in the same mountain community, of perhaps 300 inhabitants, who are all segregated by color from the surrounding population, two persons of the same name (uncommon outside the community) are absolutely *unrelated,* or unrelated outside the degree of seventh cousin. But even in a flat

[26] In justice it should be added that the remark was not made in *Biometrika.*

country, penetrated by a railroad, we find, as in the P. W. family, a large proportion of consanguineous marriages. The argument against the probability of unions with recessive albinism has not yet been presented with any force.

The third point—the lack of statistical accord between the results of human breeding and those of animals—has been often remarked upon. Bateson (1909, p. 28, footnote) believes the descent of albinism in man to be complicated by some unascertained disturbance. A careful consideration and analysis of the statistics indicates, I think, that this disturbance is to be found in the method of collecting the statistics. From the matings of two persons that are simplex in pigmentation, two sorts of families are to be expected, namely, those with albinos and those without. Since in the long run, from such parents, only one albino is produced in four offspring, it is clear that the chances are that in all families of one,

TABLE XII

GIVING ALL FAMILIES CONTAINING ALBINO OFFSPRING FROM TWO PIGMENTED CAUCASIAN PARENTS

Reference.	Offspring.				Reference.	Offspring.			
	Albinic.	Pigmented.	Total.	Per Cent. Albinic.		Albinic.	Pigmented.	Total.	Per Cent. Albinic.
She.	1	3	4	25					
Enn.	7	7	14	50	Tho.	4	4	9	60
Sac.	2	1	3	67	Wil.	1	3	4	25
Don.	2	2	4	50	P-W.a.	1	11	12	8
Ed.	1	3	4	25	P-W.a. III. 15	5	3	8	62
Far.	1	5	6	17	P-W.b. II. 2	2	7	9	22
Fer.	1	3	4	25	P-W.b. IV. 3	1	2	3	33
Hlo.	2	1	3	67	P-W.c. I. 1	1	0	1	—
Hor.	1	5	6	17	P-W. VI. 1	1	3	4	25
Huf.	1	5	6	17	P-Wd. III. 11	1	0	1	—
Lie.	1	0	1	—	P-W. IV. 1	1	12	13	7
McG.	1	0	1	—	D.G.V. II. 1	4	1	5	80
McK.	2	1	3	67	D.G.V. IV. 5	1	2	3	33
Moo.	1	1	2	50	D.G.V. VI. 10	2	8	10	20
Nea.	1	1	2	50	D.G.V. V. 24	1	3	4	25
Nog.	3	4	7	42	Men.	1	0	1	—
Ria.	3	2	5	60	Man.	6	3	9	67
					Totals.	64	107	171	374

two or three children albinism will not appear. Even in families of four or more the possible case of albinism may fail to occur. All such cases of an actual low ratio of albinism are omitted from any calculation of proportions; chiefly the accidentally high ratios are brought under consideration. The actual proportions of albinos to all offspring of two pigmented parents are given for each family in Table XII.

These 33 families together with two not plotted in the diagrams are summarized in Table XII.

TABLE XIII

THE PROPORTION OF ALBINOS IN ALBINIC FAMILIES OF DIFFERENT SIZES, WHEN NEITHER PARENT IS ALBINIC

No of Children in Family.	No. Albinic.	Per Cent. Albinism.	Families.	Total Number of Families.
1	1	100	Lie., Meg., P.W. (bis)	4
2	1	50	Moo., Nea.	2
3	2	67	Sac., Mck.	2
3	1	33	Vin., D.G.V., P.W.	3
4	2	50	Don.	1
4	1	25	She., Ed., Fer., Gur., Wil., D.G.V., P.W.	7
5	4	80	D.G.V.	1
5	3	60	Ria.	1
6	2	33	Wes.A.	1
6	1	17	For., Hor., Huf.	3
7	1	14	P.W. (not platted)	1
7	3	42	Nog.	1
8	5	63	P.W.	1
9	6	67	Man.	1
9	4	44	Tho.	1
9	2	22	P.W.	1
10	2	20	D.G.V.	1
12	1	8	P.W.	1
13	7	54	Enn.	1
13	1	8	P.W.	1
				35

Taking Table XIII in its entirety there is an average of 44 per cent. albinos to a family where expectation is 25. If we consider only the families with four or more children we find the average proportion of albinos to be 34 per cent. If we take families with six or more children the average proportion of albinos falls to 32 per

cent.; with 10 or more children to 23 per cent. On the average, with the larger families the proportion of albinos tends to approach expectation.

A second source of error is not to be neglected. When the attention of the parent or acquaintance is focused by the questioner upon albinos the albinic children are all recalled, while some normal children (such as were still-born or died in infancy) are more apt to be forgotten. I have repeatedly had the experience of bringing to mind by further questioning children that had not been at first mentioned, and they were always normal children. The records of families with only one child and that an albino are frequently due to the fact that the peculiar child is the only one recalled. Considering the high frequency of infant mortality the omission of normal children forms an important factor tending to raise the proportion of albinos.

A third possible source of error lies in imperfection of dominance, *i. e.*, the occasional failure of the pigment to show itself in the young chlidren who have it simplex. Of this imperfection there are all degrees. Thus the albinos in the LIE (No. 14) and MOO (No. 17) families have a dark retina with white hair, washed-out blue iris and nystagmus. In other cases, such as the RID family (No. 20) and P-W,A (XII, 24, 25), the hair is yellowish, while the retina is pink, or the pinkish retinal glow and nystagmus may be slight. Another fact that favors the view of frequent failure of the simplex determiner to activate fully is the progressive increase in pigmentation shown by some albinos. This is a common phenomenon. Seligsohn in Eulenburg's "Real Encyclopädie," 1880, p. 162, states: "Bei einem vongesunden Eltern mit allen Merkmalen einer Albino geborenen Kinde schwand die rothe Farbe der Iris von Jahr zu Jahr." This increase in development of a simplex character has been observed by Lang in snails, by one of us in poultry and by others.

In concluding this discussion of the causes of the aberration in the proportion of albinos I wish to urge that

what is needed in these studies is not so much a vaster number of families as more families that have been completely and accurately studied. Human pedigrees, like breeding records, are full of imperfect statements. The whole truth is to be gained only by visiting the families and carefully cross questioning them.

VII. Conclusions

What conclusions can be drawn from a study of the foregoing study of albinos?

1. Two albinic parents have only albinic offspring. This holds for the families Nos. 1–3, comprising four children altogether. These cases were all given us by Mr. R. R., an intelligent and reliable albino. He married an albino and had one son still, or until recently, living; albinic like his parents. These cases are, so far as I know, the first that have been published.

Dr. R. A. Gortner tells us that he formerly knew of a family of two albino parents and five albino children near his home in Nebraska, but attempts to trace this family have proved unsuccessful. The probability that this rule will hold generally is enhanced from experiments on animals where two albinos always yield only albino offspring.

2. Even when neither parent of albinos is an albino they are apt to be related. In 33 such families 11 are almost certainly from consanguineous matings. This is 33 per cent., a proportion that is certainly vastly greater than that of the population at large.[27] The fact that consanguinity even when present must frequently be unknown heightens the probability that parents of albinos are usually related. The importance of this conclusion is that it tends to bring these cases under the general rule that a recessive condition appears only when both parents carry the same defect; and the probability that both carry the same defect is heightened when both belong to the same strain.

[27] Lagleyze (1907) finds in 48 families of albinos consanguinity in 10, with collateral antecedents in 7, non-consanguinity in 26, and unknown 5.

3. The proportion of albinos in any family probably accords in the long run with Mendelian expectation, as in other mammals. From two non-albinic parents the proportion for families of four or more children is 34 per cent. albinos instead of the expected 25 per cent. But various causes result in an omission of normal individuals and tend to swell the proportion of the abnormal. When one parent is albinic and albino offspring occur at all we get (RID and 4 cases in P. W.), a total of 16 albinos and 15 pigmented, which accords with expectation.

STATION FOR EXPERIMENTAL EVOLUTION,
COLD SPRING HARBOR, N. Y.,
September 8, 1910.

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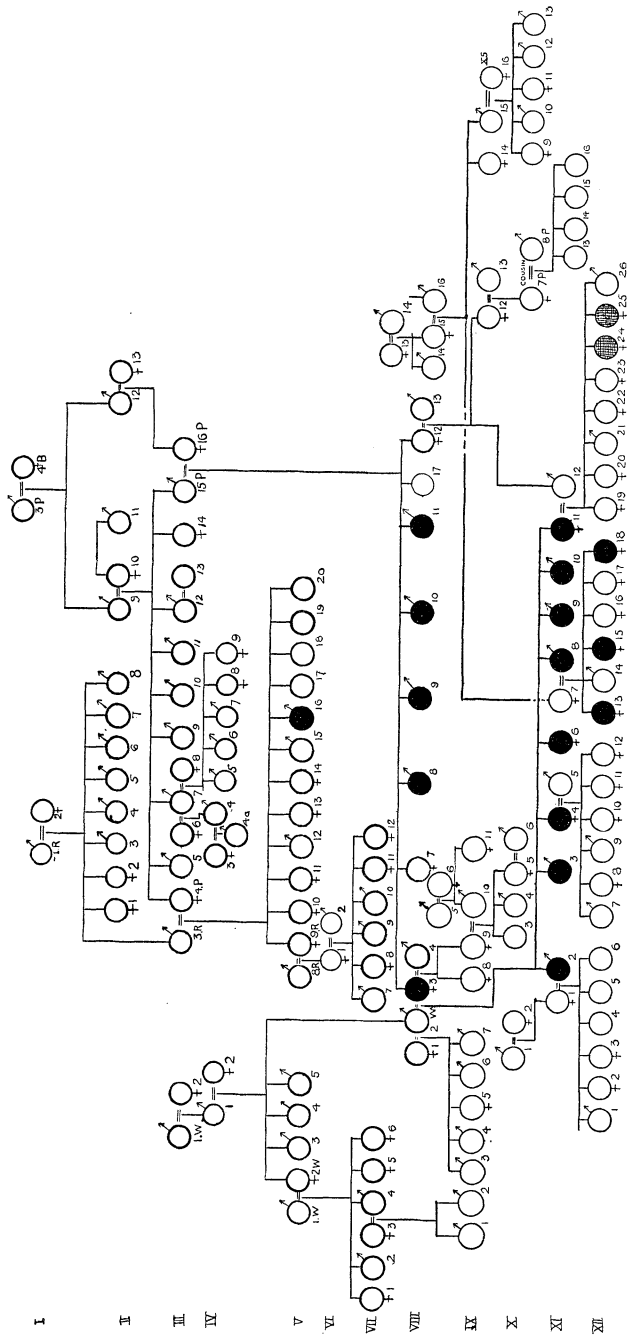
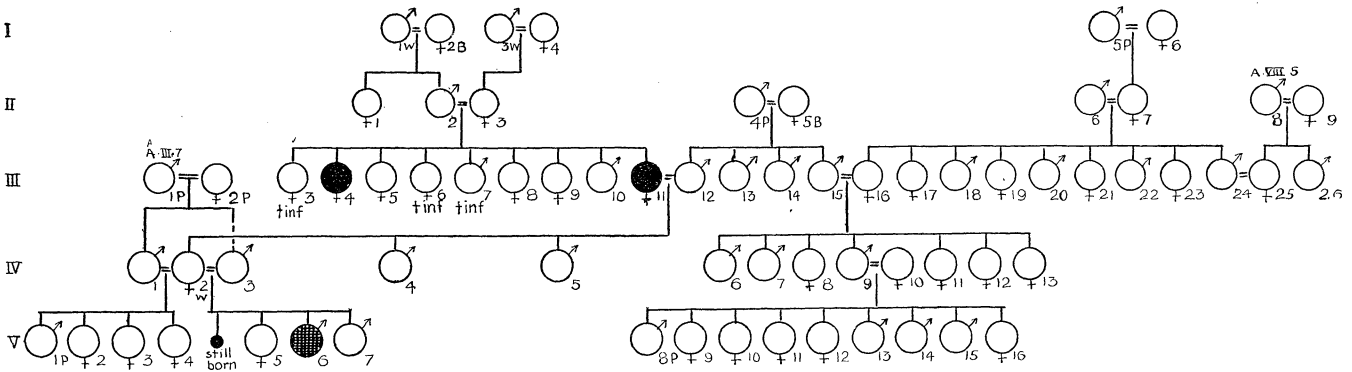
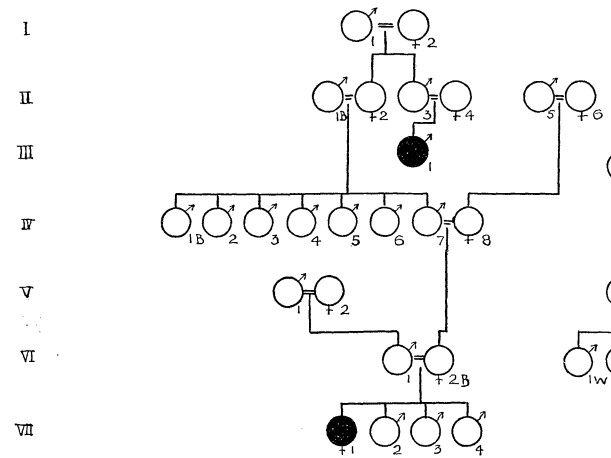


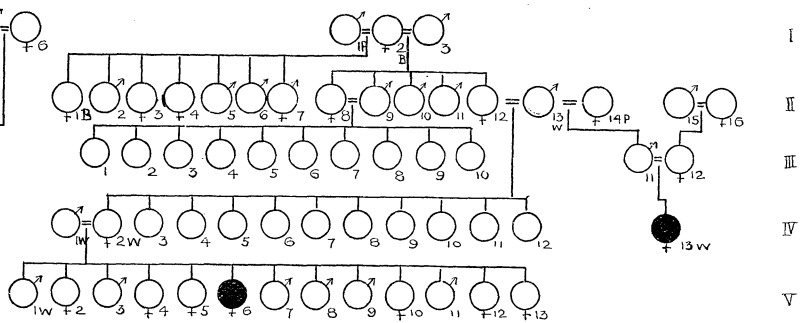
23*a* Family.



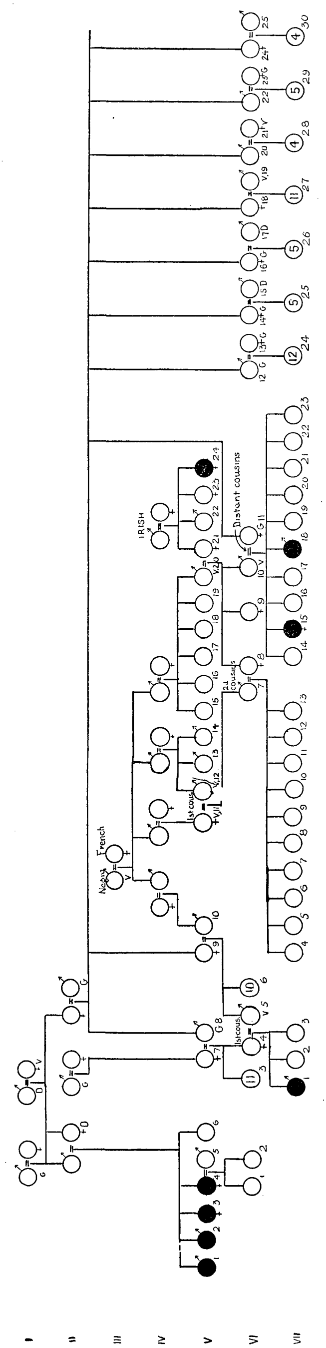
23*b* Family.



23*c* Family.



23*d* Family.


French
Negro
IRISH
Distant cousins
1st cous.
2d cousins
I
II
III
IV
V
VI
VII

D. G. V. Family